

# CLAIMS

1 1. A congested link identification system configured to be used in connection with a network for  
 2 facilitating transfer of message packets among a plurality of information utilization devices, the  
 3 network comprising a plurality of switching nodes interconnected by a plurality of communication  
 4 links, at least some of said information utilization devices being configured to transfer message  
 5 packets thereamong over paths through said network, each path comprising at least one  
 6 communication link, the congested link identification system comprising:

- 7 A. a plurality of congestion detection agents each associated with one of said information  
 8 utilization devices, each congestion detection agent being configured to generate congested  
 9 path information indicating whether respective paths used by the information utilization  
 10 device associated with the respective congestion detection information are congested; and  
 11 B a congestion link identification processor configured to process the congestion detection  
 12 information generated by the congestion detection agents to identify communication links  
 13 that are congested.

1 2. A congested link identification system as defined in claim 1 in which at least one of said  
 2 congestion detection agents is configured to generate congested path information in connection with  
 3 one of said paths utilized by the information utilization device with which said at least one of said  
 4 congestion detection agents is associated, the congested path information being in relation to the  
 5 time period for at least one message packet transferred over said path.

1 3. A congested link identification system as defined in claim 1 in which at least one of said  
 2 congestion detection agents is configured to generate congested path information in connection with

3 congestion information received by the information utilization device with which said at least one  
4 of said congestion detection agents is associated.

1 4. A congested link identification system as defined in claim 1 in which said congestion link  
2 identification processor is configured to determine that a communication link is congested if  
3 congested path information indicates that all paths that utilize said communication link is congested.

4 5. A congested link identification system as defined in claim 4 in which said congested link  
5 identification processor comprises:

6 A. a network connectivity graph generation module configured to generate a network  
7 connectivity graph describing the topology of at least a portion of the network from the  
8 congested path information, the network connectivity graph including a plurality of vertices  
9 each associated with one of said switching nodes and edges each associated with one of said  
10 communication links;

11 B. an edge link labeling module configured to label the edges in the graph, each edge being  
12 labeled as being congested if the congested path information indicates that all of the paths  
13 that utilize the communication link associated with that edge are congested, and otherwise  
labeling the edge not congested; and

C. a graph pruning module configured to prune the graph of edges that are labeled not  
congested, the edges that are not pruned being congested.

1 6. A congested link identification system as defined in claim 5 in which the graph pruning module  
2 is configured to prune the graph using a depth first search pruning methodology.

1 7. A congested link identification processor configured to process congested path information  
 2 indicating whether paths in a network are congested, the network comprising a plurality of switching  
 3 nodes interconnected by communication links, each path including at least one communication link,  
 4 the congested link identification processor comprising:

- 5 A. a network connectivity graph generation module configured to generate a network  
 6 connectivity graph describing the topology of at least a portion of the network from the  
 7 congested path information, the network connectivity graph including a plurality of vertices  
 8 each associated with one of said switching nodes and edges each associated with one of said  
 9 communication links;  
 10 B. an edge link labeling module configured to label the edges in the graph, each edge being  
 11 labeled as being congested if the congested path information indicates that all of the paths  
 12 that utilize the communication link associated with that edge are congested, and otherwise  
 13 labeling the edge not congested; and  
 14 C. a graph pruning module configured to prune the graph of edges that are labeled not  
 15 congested, the edges that are not pruned being congested.

1 8. A congested link identification system as defined in claim 7 in which the graph pruning module  
 2 is configured to prune the graph using a depth first search pruning methodology.

1 9. A method of detecting congested communication links in a network, the network facilitating  
 2 transfer of message packets among a plurality of information utilization devices, the network  
 3 comprising a plurality of switching nodes interconnected by a plurality of communication links, at

least some of said information utilization devices being configured to transfer message packets thereamong over paths through said network, each path comprising at least one communication link, the method comprising the steps of:

- A. generating in connection with each of said information utilization devices, congested path information indicating whether respective paths used by the respective information utilization device are congested; and
- B. processing the congestion detection information generated by the congestion detection agents to identify communication links that are congested.

10. A method as defined in claim 9 in which congested path information is generated in connection with one of said paths utilized by the respective information utilization device, the congested path information being in relation to the time period for at least one message packet transferred over said path.

11. A method as defined in claim 9 in which congested path information is generated in connection with congestion information received by the respective information utilization device.

12. A method as defined in claim 9 in which said congestion link identification processor is configured to determine that a communication link is congested if congested path information indicates that all paths that utilize said communication link is congested.

13. A method as defined in claim 12 in which said congested link identification step comprises the steps of:

- A. generating a network connectivity graph describing the topology of at least a portion of the network from the congested path information, the network connectivity graph including a plurality of vertices each associated with one of said switching nodes and edges each associated with one of said communication links;
- B. labeling the edges in the graph, each edge being labeled as being congested if the congested path information indicates that all of the paths that utilize the communication link associated with that edge are congested, and otherwise labeling the edge not congested; and
- C. pruning the graph of edges that are labeled not congested, the edges that are not pruned being congested.

14. A method as defined in claim 13 in which the graph pruning step includes the step of pruning the graph using a depth first search pruning methodology.

15. A method of processing congested path information indicating whether paths in a network are congested, the network comprising a plurality of switching nodes interconnected by communication links, each path including at least one communication link, the method comprising the steps of:

- A. generating a network connectivity graph describing the topology of at least a portion of the network from the congested path information, the network connectivity graph including a plurality of vertices each associated with one of said switching nodes and edges each associated with one of said communication links;

- 8 B. labeling the edges in the graph, each edge being labeled as being congested if the congested
- 9 path information indicates that all of the paths that utilize the communication link associated
- 10 with that edge are congested, and otherwise labeling the edge not congested; and
- 11 C. pruning the graph of edges that are labeled not congested, the edges that are not pruned being
- 12 congested.

1 16. A method as defined in claim 15 in which the graph pruning step includes the step of pruning  
2 the graph using a depth first search pruning methodology.

3 17. A computer program product for use in connection with a computer to provide a congested link  
4 identification system configured to be used in connection with a network for facilitating transfer of  
5 message packets among a plurality of information utilization devices, the network comprising a  
6 plurality of switching nodes interconnected by a plurality of communication links, at least some of  
7 said information utilization devices being configured to transfer message packets thereamong over  
8 paths through said network, each path comprising at least one communication link, the computer  
9 program product comprising a computer-readable medium having encoded thereon:

- 8 A. a congestion detection agent module configured to enable said computer to provide a
- 9 plurality of congestion detection agents each for association with one of said information
- 10 utilization devices, each congestion detection agent being configured to generate congested
- 11 path information indicating whether respective paths used by the information utilization
- 12 device associated with the respective congestion detection information are congested; and
- 13 B a congestion link identification processor module configured to enable the computer to
- 14 process the congestion detection information generated by the congestion detection agents
- 15 to identify communication links that are congested.

1 18. A computer program product as defined in claim 17 in which at least one of said congestion  
 2 detection agents is configured to generate congested path information in connection with one of said  
 3 paths utilized by the information utilization device with which said at least one of said congestion  
 4 detection agents is associated, the congested path information being in relation to the time period  
 5 for at least one message packet transferred over said path.

1 19. A computer program product as defined in claim 17 in which at least one of said congestion  
 2 detection agents is configured to generate congested path information in connection with congestion  
 3 information received by the information utilization device with which said at least one of said  
 4 congestion detection agents is associated.

1 20. A computer program product as defined in claim 17 in which said congestion link identification  
 2 processor module is configured to enable the computer to determine that a communication link is  
 3 congested if congested path information indicates that all paths that utilize said communication link  
 4 is congested.

1 21. A computer program product as defined in claim 20 in which said congested link identification  
 2 processor module comprises:

3 A. a network connectivity graph generation module configured to enable the computer to  
 4 generate a network connectivity graph describing the topology of at least a portion of the  
 5 network from the congested path information, the network connectivity graph including a

plurality of vertices each associated with one of said switching nodes and edges each associated with one of said communication links;

- B. an edge link labeling module configured to enable the computer to label the edges in the graph, each edge being labeled as being congested if the congested path information indicates that all of the paths that utilize the communication link associated with that edge are congested, and otherwise labeling the edge not congested; and
- C. a graph pruning module configured to enable the computer to prune the graph of edges that are labeled not congested, the edges that are not pruned being congested.

22. A congested link identification system as defined in claim 21 in which the graph pruning module is configured to enable the computer to prune the graph using a depth first search pruning methodology.

23. A computer program product for use in connection with a computer to provide a congested link identification processor configured to process congested path information indicating whether paths in a network are congested, the network comprising a plurality of switching nodes interconnected by communication links, each path including at least one communication link, the computer program product comprising a computer readable medium having encoded thereon:

- A. a network connectivity graph generation module configured to enable the computer to generate a network connectivity graph describing the topology of at least a portion of the network from the congested path information, the network connectivity graph including a plurality of vertices each associated with one of said switching nodes and edges each associated with one of said communication links;



- 11 B. an edge link labeling module configured to enable the computer to label the edges in the
- 12 graph, each edge being labeled as being congested if the congested path information
- 13 indicates that all of the paths that utilize the communication link associated with that edge
- 14 are congested, and otherwise labeling the edge not congested; and
- 15 C. a graph pruning module configured to enable the computer to prune the graph of edges that
- 16 are labeled not congested, the edges that are not pruned being congested.

1 24. A computer program product as defined in claim 23 in which the graph pruning module is  
configured to enable the computer to prune the graph using a depth first search pruning  
methodology.